Mobile Power Utilizing Electromagnetics & Natural Energy Sources

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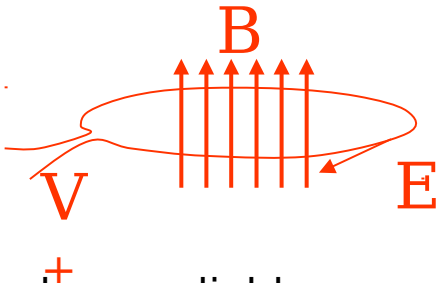
2003 Tri-Service Expo

Norfolk, VA

Electromagnetic Energy Sources

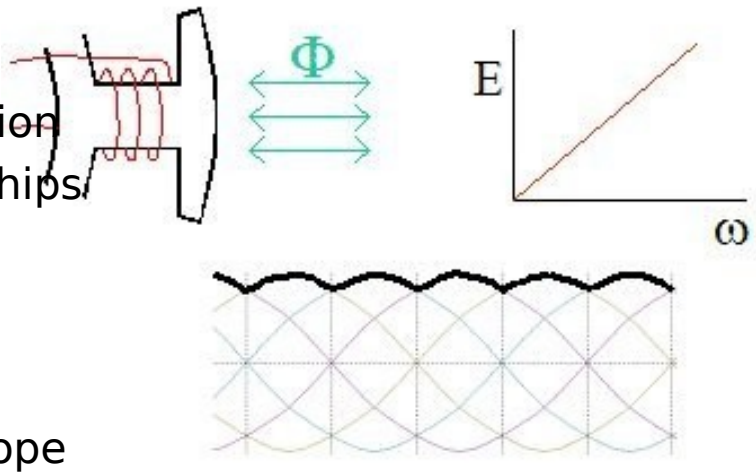


$$\oint \bar{E} \bullet d\bar{L} = -\int_S \frac{\partial \bar{B}}{\partial t} \bullet d\bar{S}$$

- Faraday's Law
  - Over 100 years old
  - Rock solid, proven technology, reliable
  - Proven manufacturability, cheap, widely available
- 99+% of All Electricity Generated This Way
  - Forcefully turned shaft moves magnetic fields near wires inducing electrical current flow
  - Induction motors (steel & wire)
  - Brush Permanent Magnet (steel, wire, magnets, brushes)
  - Now Brushless DC (steel, wire, magnets, electronics), highest efficiency & density
- Strong Commercial Industry in sub-50W BLDC's
  - CE: Printers, copiers, material handling, servos
  - Hard Disk Drives – 50% all NdBFe rare-earth magnets
  - HDDs - all the industry R&D, 200+M units/yr
  - Smallest, most powerful & efficient

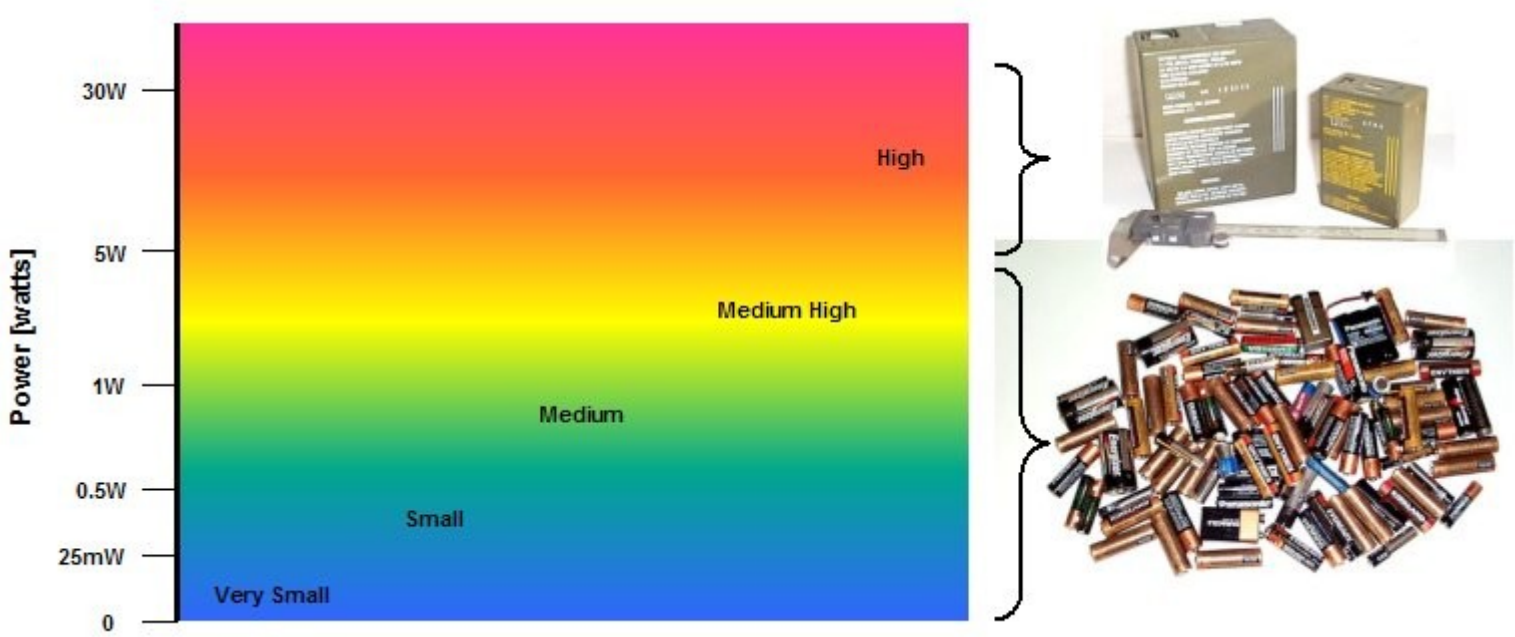
BLDC Industry Developments

- Falling Costs
  - NdBFe magnet patents expiring
  - Foreign mfg. sources – China
  - Commutation electronics integration
  - High efficiency power converter chips
  - High precision mfg
  - No more cost penalty
- Improving Design Techniques
  - BLDC systems & design – US, Europe
  - Magnet R&D – Japan, Germany
- Large Consumer Electronics Adoption
  - High volumes, low costs
  - Many high quality, world-class suppliers
  - Integrated Circuit Devices

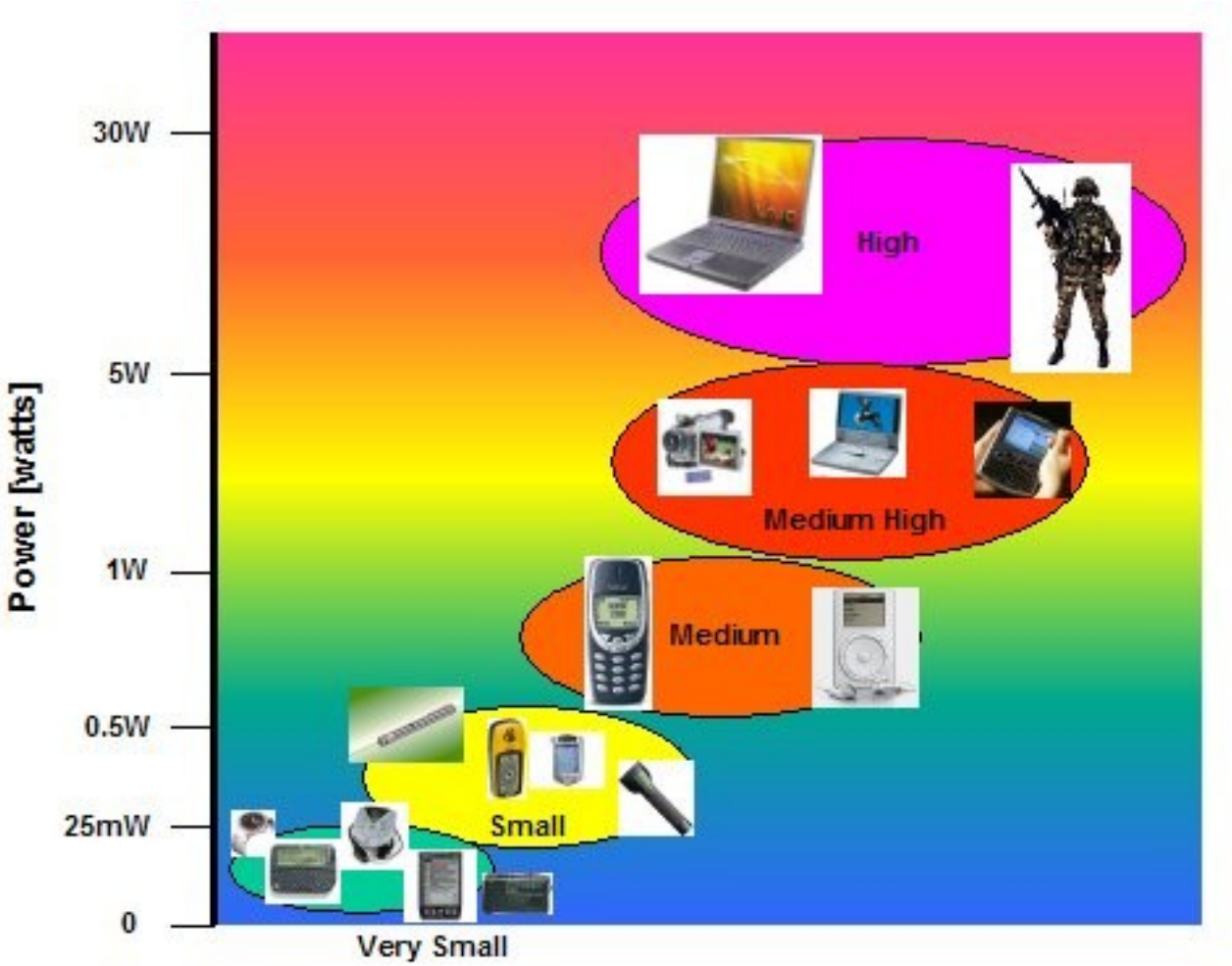


Mobile Power Requirements

- Consumer & Commercial Electronics
  - Major driver of all mobile technology – electronics, power conversion, batteries
  - Which devices achieve mobility
- How many watts to do something useful?



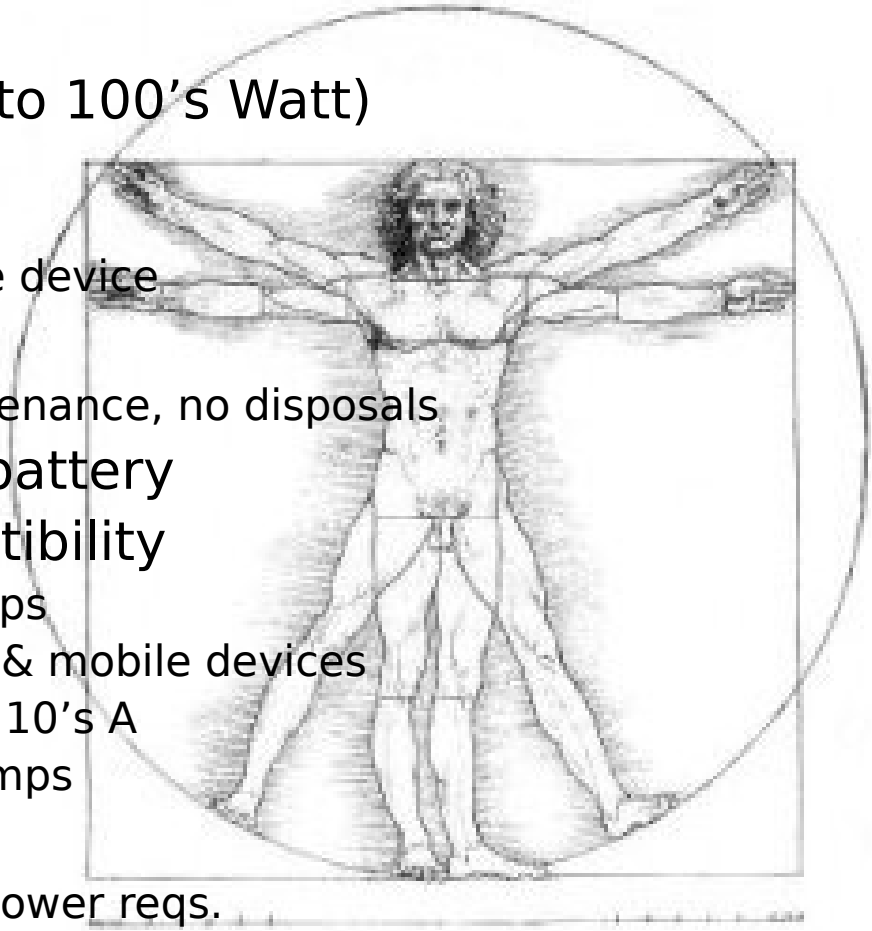
Mobile Power Requirements



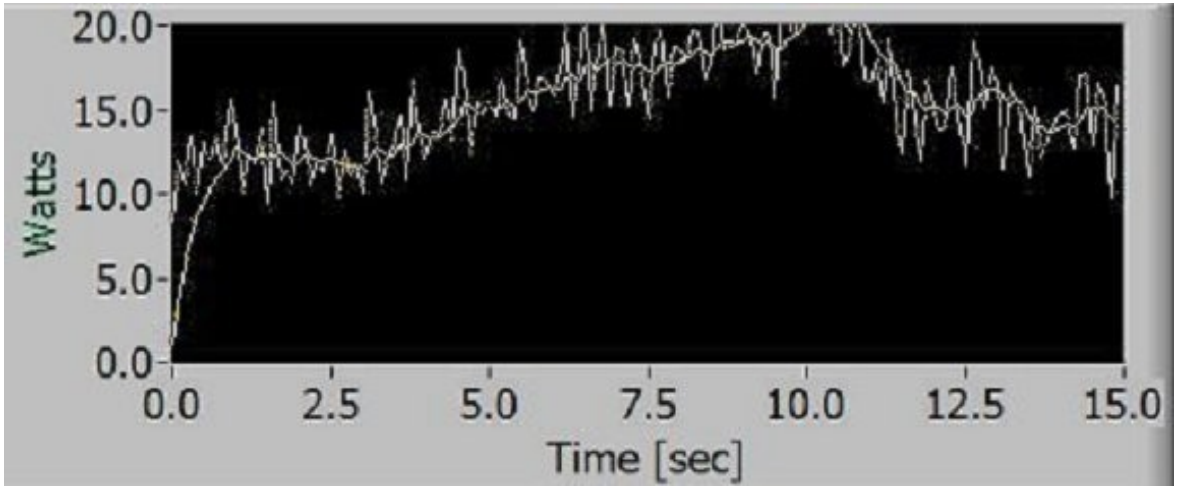
1. Becomes mobile
2. Reduces power over time

Human Power Sources

- High power (10's to 100's Watt)
  - 150W from legs
  - 15W from arms
  - Powers any mobile device
- Always available
  - No fuels, no maintenance, no disposals
- 1 Calorie = 1 AA battery
- E-M power compatibility
  - 5-30 Volts, 1-5 Amps
  - Matches batteries & mobile devices
  - Photovoltaic 0.6V, 10's A
  - Piezo 200V, milliamps
- Favorable Trends
  - Reducing mobile power reqs.



Human Power Requirements



- Limitations - time, magnitude, speed (2Hz)
  - Varies, fatigues, takes breaks, gets bored
  - Force not Power
- Ergonomics
  - Efficiency - convert as much as possible to electricity
  - **Portability < 0.5Kg**
  - Comfortable operation

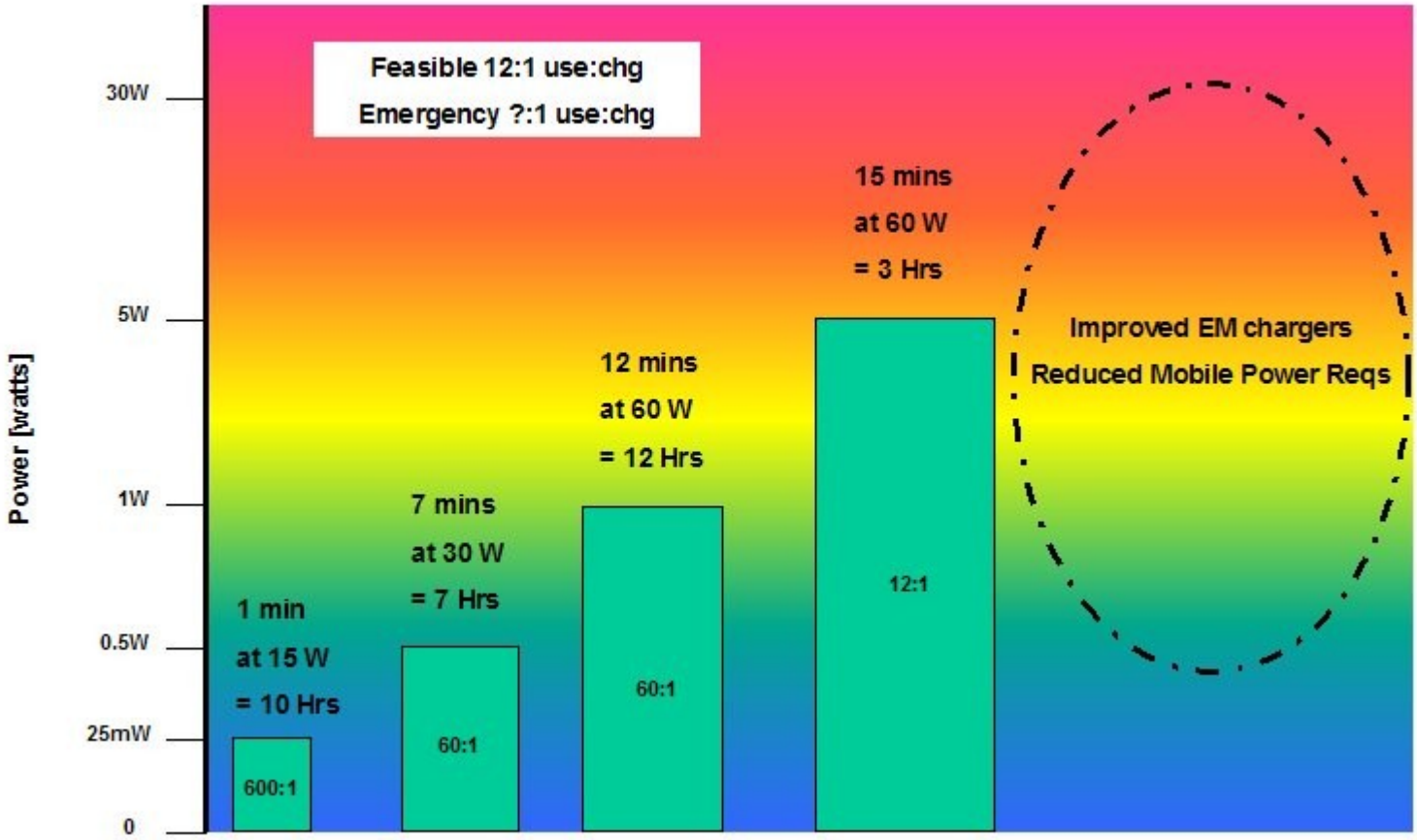
Human Power Requirements (cont.)

- High charge rate batteries
  - Capacity & size is OK (CE focus)
  - Maximum charge rates are somewhat low (unless very large)
    - A123systems, Rayovac IC3, Supercapacitors
  - Can overcharge & damage smaller batteries

BB-390A/U
NiMH
12/24 volts
capacity: 86.4 W-hr (@0.75A)
2 hr fast charge - 43.2 W
12 hr std. charge - 8.6 W
1%/day self-discharge

BB-2847/U
Li-ion
8 volts
capacity: 28.8 W-hr (@1.8A)
2 hr fast charge - 14.4 W
4 hr std. charge - 7.2W
2 yr chemistry life

Manual Power Feasibility



Conclusions

- BLDC's Rapid Adoption
  - Falling NdBFe costs – no premium over conventional
  - Design technology – drastic size reductions & power increases
- Human + E-M Energy Harvesting
  - High wattage drives all mobile electronics devices
  - Flexible output charges all battery chemistries & directly drives devices
  - Ideal for emergency use – rugged, no fuels, no maintenance, no disposal
- Favorable Trends
  - Steadily reducing mobile electronics power
  - Improving E-M designs & materials
  - Rapid-charging chemical batteries
  - Consumer acceptance ($60M/yr radios & lamps)

Proven, Practical, Available

You'll See It More & More !